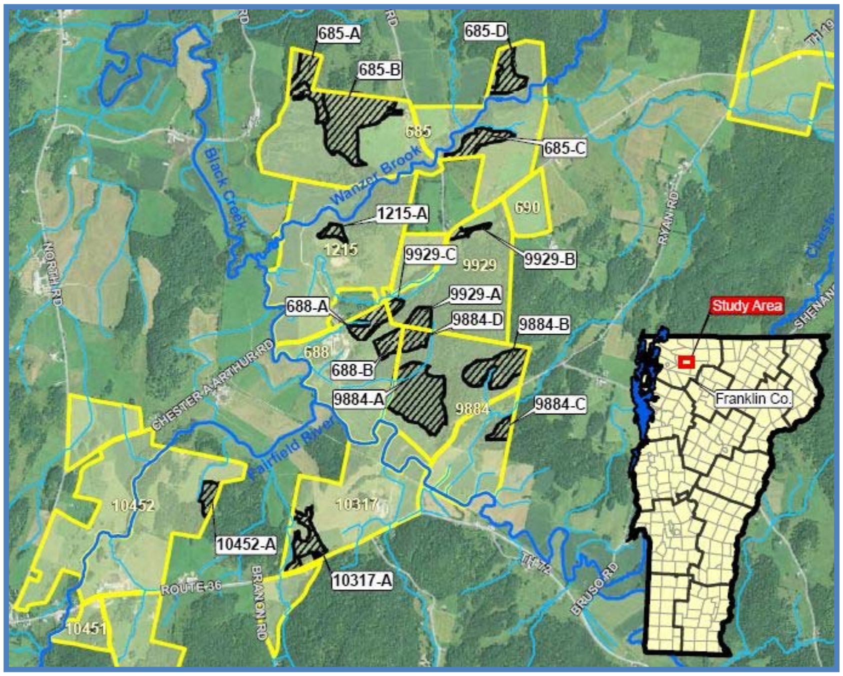

PROACTIVE FARM MANAGEMENT PLAN:

NFAST

A GIS MODEL
FOR CONVERTING NEW CROPLANDS
WHILE MINIMIZING IMPACTS TO
WETLANDS AND SIGNIFICANT NATURAL RESOURCES

DRAFT – 10/01/10

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Introduction

The dairy industry in Vermont has experienced financial pressure over the past decade, with approximately 171 farms going out of business between 2002 and 2007 (U.S. Department of Agriculture, 2007). For some dairy farmers, sustainable financial operations include the expansion of their milking herd, which, in turn, increases feed demands. The feed demands can be met by either off-farm purchases of hay and corn or by increasing the quantity of hay and corn grown on the farm. The most cost effective approach for many farms is to grow more of their crops, but this requires the conversion of open or forested land to cropland. The process of converting these lands into productive croplands generally involves ditching, grading, installation of tile drains, and tillage activities (among other agricultural practices) that can impact wetlands or affect the drainage patterns of water. Thus, farmers are required by federal and state law to obtain an Army Corps of Engineers (Corps) 404 Water Quality Certification (hereinafter referred to as the "Corps Permit").

For many farmers, the Corps Permit is perceived as a complex and lengthy undertaking, as it involves the delineation of wetlands across a large landscape; the quantification of impacts to wetlands due to their conversion to productive cropland; and the costs associated with preparing and implementing mitigation projects. The Corps Permit process can take multiple years to complete, during which time economic conditions may induce farmers to delay or abandon expansion plans. As a result of the perceived complexity, many dairy farmers have been reluctant to embark on herd expansion and land clearing projects. Other farms have converted land to cropland without approval and are at risk of violating existing laws or losing benefits through Farm Service Agency programs.

The Vermont Agency of Natural Resources Center for Clean and Clear (Clean and Clear) instigated an interagency working group (Working Group) tasked with reducing the complexity of the Corps Permit process and the length of time it takes to complete the permit, all the while minimizing impacts to wetlands and natural resources. The Working Group consisted of federal and state regulatory agencies. The federal agencies included the Corps, the Natural Resource Conservation Service (NRCS), and the Environmental Protection Agency (EPA). In addition to the Center for Clean and Clear, the state regulatory bodies included the Agency of Agriculture, Food, & Markets (VAAFM) and the Department of Environmental Conservation (DEC).

In the summer of 2009, Clean and Clear contracted with Vermont Wetland Plant Supply, LLC and its team of consultants (Fitzgerald Environmental Associates, LLC, Shelley Gustafson Environmental, LLC, Waste Not Resource Solutions, and Alicia Daniel) to develop a geographic information system (GIS) tool that would be used by farmers and NRCS regulators to simplify the Corps permit process. This tool would also assist in selecting conservation and restoration sites that further water quality goals of the state of Vermont. Clean and Clear also selected the Magnan Brothers Dairy, Inc. in Fairfield, Vermont as the pilot farm to test the capabilities of the GIS tool.

Objectives

The objectives in developing a GIS program that would simplify the Corps Permit process are as follows:

1) Establish an easy-to-understand methodology for dairy farmers and GIS operators to efficiently identify potential new parcels of desirable cropland by combining on-the-ground knowledge (provided by the dairy farmer) with digital agricultural information.
2) Establish a series of quantitative factors using geospatial databases that will identify areas that contain or would potentially contain wetlands and natural resources that are evaluated by state and federal regulators during the Corps Permit review process.
3) Minimize impacts to wetlands and natural resources by avoiding, to the greatest extent possible, parcels with large wetland areas and natural resources or by redefining parcel boundaries.

Project Approach

GIS Basics

Geographic information systems (GIS) are computer programs that analyze and display data about any location with a geospatial identity. The strength of a GIS lies in its ability to take data from numerous sources about a specific point on the globe, relate the data according to instructions provided by the user, and produce an outcome or conclusion about the specific location.

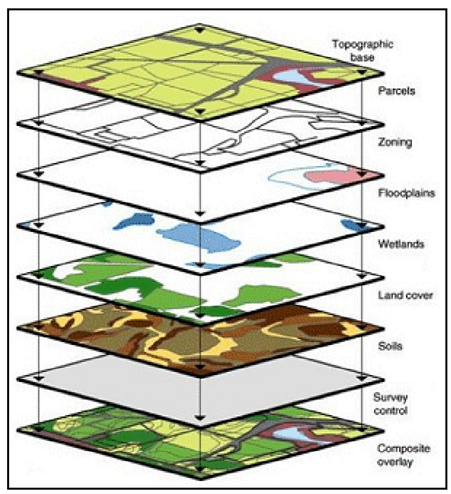

Figure 1: Data from numerous GIS layers is used to develop comprehensive information about single or multiple parcels of land.

Databases with multitudes of information can (and should) be thought of as layers (See Figure 1). These layers are produced by federal, state, local agencies, and in many cases, the user. Specific information within each layer can be compiled to produce a single composite overlay. For example, in Figure 1, information from seven different layers (topographic, parcels, zoning, floodplains, wetlands, land cover, and soils) is analyzed according to the user's instructions in order to produce an answer to a specific question. In this case, the user may have wanted to identify all lands 1) below a certain elevation (information contained in the topographic base layer); 2) that are undeveloped (parcel layer); 3) within the commercially zoned land (zoning layer); 4) outside of floodplain boundaries (floodplain layer); 5) have upland soil (wetlands layer); 6) are not old growth forests; and 7) have soils that support septic systems. The outcome/result of the user query is not only displayed graphically on the screen as the composite overlay, but also in tabular format in a new database file (such as a Microsoft Excel .xls file).

The project team and the Working Group sought to develop a GIS program that would work in a similar fashion to answer the following question: what lands could be converted to productive cropland with the least impacts to wetlands and natural resources?

The NFAST Program

The project team developed a GIS model informally named "NFAST", which is an acronym for Natural Resource Farm Assessment and Screening Tool. The NFAST program analyzes the potential cropland productivity on specific parcels of open or forested landscapes and the wetlands and other natural resources that exist or potentially exist on those parcels. As described above in *GIS Basics*, a GIS answers (outcome) questions by querying information (input) contained within digital databases. The quality of the answer greatly depends upon the richness, resolution and age of the information contained within the databases. It reasons that if the information within the database is of little value (i.e., outdated), then the outcome will have little utility. Therefore, the critical first step in developing NFAST was to identify the appropriate databases to be used in the program.

The databases can be categorized based on how they are used to meet the project objectives. The first two project objectives addressed information valued by two different groups: the dairy farmers and the regulatory agencies. The dairy farmers seek to identify the optimal lands for conversion into productive cropland. The regulatory agencies seek to identify the wetlands and natural resources that exist or potentially exist within those parcels. Both groups can obtain answers by examining individual factors that can collectively be thought of as "*constraints*." The individual factors that help the dairy farmer identify the optimal lands are known as "**producer constraints**", while the individual factors that determine the extent of wetlands and natural resources are known as "**natural resource constraints**."

The producer constraints and the natural resources are graphically depicted in Figure 2 on the following page. The dairy farmer uses eight different factors to help identify the optimal lands. Many of the factors relate to the soil series, as described in the Soil Survey of Franklin County, Vermont (U.S.D.A. Soil Conservation Service, 1979). Other factors, such as field size and proximity to home farm, relate to the economics that the dairy farmer takes into consideration when identifying the optimal lands. The regulatory agencies use 11 different factors to help identify the natural resources that exist or potentially exist within the parcels identified as optimal by dairy farmer. Descriptions of all the factors along with the rational for inclusion in the NFAST program are found in the sections following Figure 2.

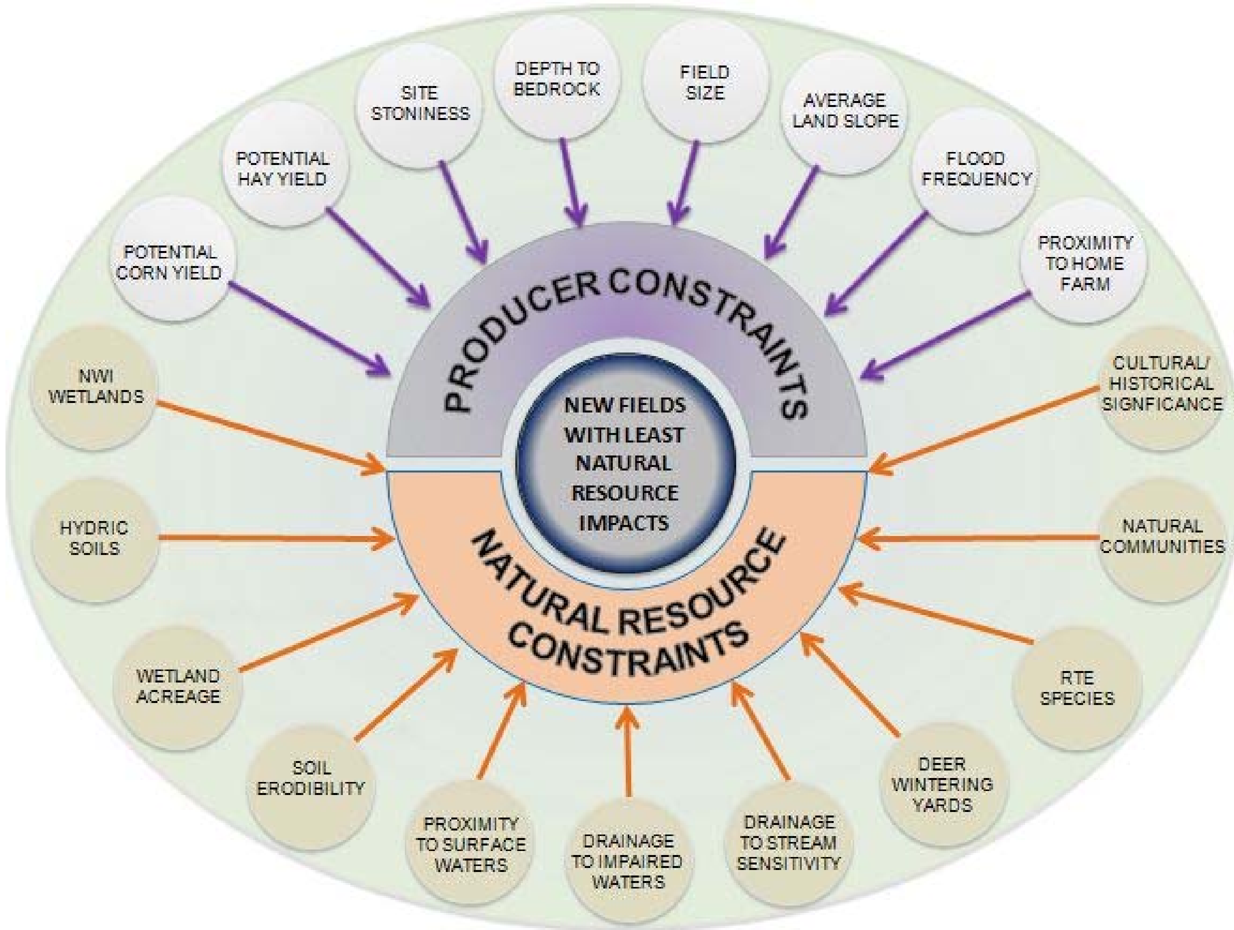

Figure 2: GIS model producer and natural resource constraints

PRODUCER CONSTRAINTS

Producer constraints are the factors that determine if a given parcel is a candidate for conversion to cropland or pasture. The two primary factors are the potential corn and hay yields (in tons per acre per year), as a producer would primarily be interested in converting lands that offer the greatest yield potential. However, other factors such as site stoniness, depth to bedrock, land slope, and flooding frequency, can influence the cost of conversion and offset the potential benefits of converting a parcel with high potential yields. Lastly, factors such as proximity to home farm and parcel size can prioritize which parcels are candidates. For instance, the producer may elect to convert a parcel that is large but with moderate corn and hay productivity rather than a small parcel with a high productivity because the total yield on the larger parcel is greater than the total yield on the smaller parcel.

The following section describes each factor, the rational for including the factor as a producer constraint, the scoring system, and the data source for inclusion in the GIS model.

Corn Silage Potential Yield

Corn silage potential yield is the average annual yield in tons per acre for each soil type. The yield is based mainly on the experience and records of farmers, conservationists, and extension agents (United States Department of Agriculture Soil Conservation Service, 1961).

Corn silage is included in the model as corn is one of the most important silage foods for dairy herds.

The scoring regime for corn silage potential yield is illustrated in Figure 3. The scoring regime is separated into five categories limited by the minimum (10 tons per year) and maximum (greater than 26 tons per year) values reported in the Soil Survey of Franklin County, Vermont (U.S.D.A. Soil Conservation Service, 1979).

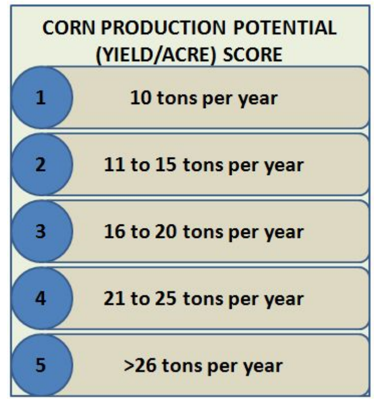

Figure 3: Scoring regime for corn production potential (yield per acre) on a potential cropland conversion parcel.

Potential Hay Yield

Potential hay yield is the average annual yield in dry tons per acre for each soil type. The hay type is grass-legume unless no yield value exists, in which case alfalfa hay yield is used. As with the corn silage, the yield is based on the experience and records of farmers, conservationists, and extension agents.

Hay production is included as it is the most common feed grown for the dairy herd. Legume-grass hay is used most frequently in Vermont due to its adaptability to the climate conditions. Yields for alfalfa-hay are used when yields from legume-grass hay are not available.

The scoring for potential hay yields (see Figure 4) is based on the minimum and maximum values identified in the Soil Survey for Franklin County, Vermont.

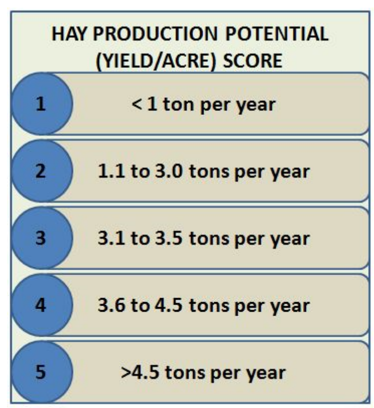

Figure 4: Scoring regime for hay production potential (yield per acre) on a potential cropland conversion parcel.

Site Stoniness

Site stoniness describes the presence of coarse fragments with a diameter greater than 3 inches (75 mm) within the first 10 inches (25 cm) of the soil surface, expressed as a percentage of the soil volume.

As coarse rock fragments hinder tillage, plant root development, and harvesting, dairy farmers search for lands that have low percentages of rock fragments. Coarse rock fragments can be removed from a field but often at considerable expense to the dairy farmer.

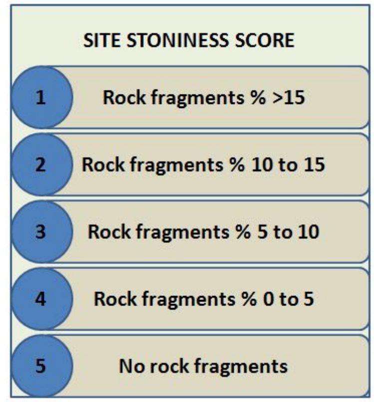

Figure 5: Scoring regime for the site stoniness of a potential cropland conversion parcel.

Five categories were used to score a parcel's site stoniness (see Figure 5). Parcels where the rock fragments exceeded 15 percent of the soil volume receive a score of 1, while parcels without rock fragments score 5 points. Rock fragment percentages of 0 to 5, 5 to 10, and 10 to 15 earn scores of 2, 3 and 4, respectively.

Depth to Bedrock

Depth to bedrock is the distance from the soil surface to the fixed rock material (bedrock, stone or boulder material that is not readily excavated) that adversely affects the agricultural use.

Depth to bedrock is a soil characteristic critical to dairy farmers looking for tillable acres. When the depth to bedrock is shallow, tilling is impractical or economically prohibitive, as the bedrock material would need to be excavated prior to tilling the land. Depth to bedrock can also affect rates of drainage and may create perched wetlands above the adjacent water table.

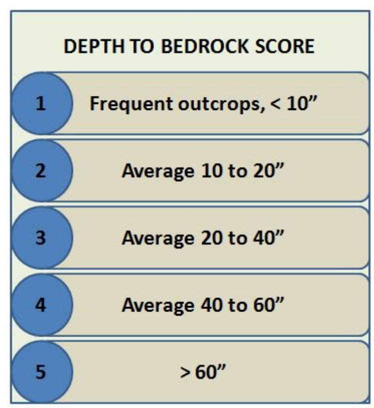

Figure 6: Scoring regime for the depth to bedrock of a potential cropland conversion parcel.

The scoring, as shown in Figure 6 is based on five ranges of depth described in the Soil Survey of Franklin County, Vermont (USDA SCS 1979).

Flood Frequency

Flood frequency relates to the temporary covering of soil with water from overflowing streams and runoff from adjacent slopes and how often the flooding occurs (U.S.D.A. Soil Conservation Service, 1979).

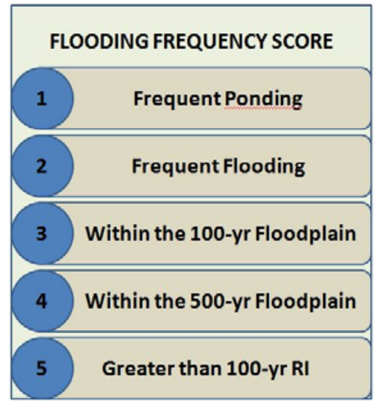

Figure 7: Scoring regime for the flood frequency of a potential cropland conversion parcel.

Lands that frequently experience flooding and ponding often contain highly productive soils, as floodwaters deposit nutrient rich sediment in the floodplain. However, parcels that frequently flood often are inaccessible to farming equipment, leading to delays in seeding and tilling. Additionally, crops may be vulnerable to damage or destruction if flooding occurs during the growing season. Lands that flood frequently and with long duration often support wetlands.

The scoring regime, as shown in Figure 7, is based on soil survey categories of frequency and duration of ponding and flooding in combination with regional FEMA flood mapping. Frequency and duration is determined by areas adjacent rivers and streams that are susceptible to long-term ponding or inundation from floodwaters (scores 1 and 2, respectively). Less frequently flooded sites affected by unusual weather conditions that generate 100 and 500-year flood events are scored higher (3 and 4, respectively), while areas outside of floodprone areas receive a score of 5.

Average Land Slope

Land slope is defined as the inclination of the land surface from the horizontal. Slope is expressed as a percentage of the vertical distance divided by horizontal distance, multiplied by 100.

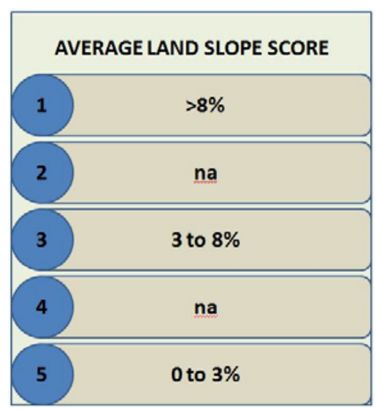

Figure 8: Scoring regime for the average land slope of a potential cropland conversion parcel.

Land slope affects the ability of the dairy farmer to use tractors to till, seed the land and harvest the crop. Steeper lands (greater than 8 percent slope) are generally considered unworkable, while lands with slopes between 3 and 8 percent are generally thought to be at the upper range of slopes accessible to tractors and other farm implements.

The scoring regime (see Figure 8) is based on three classes of slope. Lands with 0 to 3 percent slope are considered nearly level and earn a score of five. Lands with slopes ranging between 3 and 8 percent are considered gently sloping and earn a score of 3. Lands with slopes greater than 8 are considered strongly sloping and earn a score of 1.

Proximity to Home Farm

Proximity to home farm is the distance (via town or farm roads) of a parcel from the home farm where the milking herd resides, particularly during the winter months, when food is brought to the herd.

A parcel's proximity to the home farm influences transportation and hauling costs, as the dairy farmer will spend more money in fuel to plow, seed, and harvest a crop at a parcel that is further away from the home farm than at a parcel adjacent to the home farm.

PROXIMiTY TO HOME FARM SCORE	
1	> 10 miles
2	5 to 10 miles
3	2.5 to 5 miles
4	0.5 to 2.5 miles
5	< 0.5 miles

Figure 9: Scoring regime for the proximity to the home farm of a potential cropland conversion parcel.

The scoring system (see Figure 9) is based on discussions with regional dairy farmers about the maximum distance a parcel would be from the home farm before it was deemed unfeasible to cultivate crops. Parcels that are greater than 10 miles from the home farm would earn a score of one, while parcels that are within one half mile of the home farm would earn a score of five.

Field Size

Field size measures the size of the parcel, in acres. The size of the field can influence the dairy farmer's decision on which parcels should be converted to cropland. For example, if the dairy farmer could only convert one of two parcels to cropland, a 20 acre parcel with medium corn silage and hay yields would be more attractive to convert than a 3 acre parcel with high corn silage and hay yields.

FIELD SIZE SCORE	
1	< 5 acres
2	5 to 10 acres
3	10.1 to 15 acres
4	15.1 to 20 acres
5	> 20 acres

Figure 10: Scoring regime for the field size of a potential cropland conversion parcel.

The field size scoring (see Figure 10) is divided into five categories with increments of five acres separating the categories. A field size of less than five acres merits a score of one; while a field size of 20 or more acres merits a score of five.

Natural Resource Constraints

NWI Wetlands and Delineated Wetlands

This factor uses the relative proximity of wetlands identified by the National Wetlands Inventory (NWI) maps (produced by the U.S. Fish and Wildlife Service) to represent the extent of wetland coverage within a given parcel. In cases where on-the-ground wetland boundary determinations have been conducted and the corresponding survey data are available, the field-delineated boundaries are used in place of the NWI polygons.

The NWI database provides useful information regarding the relative location and size of wetlands within a given area. However, it is not considered comprehensive. The NWI is based on the evaluation of aerial photography. Wetlands smaller than 0.5 acre in size, as well as wetland systems where hydrology is more difficult to discern via aerial photography (e.g., forested swamps), can be overlooked. Because NWI wetland boundaries are approximate, the ranking scheme for this factor is based on broad categories (e.g. greater than 50 percent coverage of site and less than 50 percent coverage of site are used to distinguish the top two scores for this factor). Should actual field-delineated boundaries be available for a given site, these data are considered more accurate and are used in place of the NWI data.

A site scores either 1 or 2 if an NWI polygon actually overlaps with a portion of a given site (scoring 1 if the polygon covers greater than 50 percent of the site and 2 if it covers less than 50 percent of the site). If the NWI polygon doesn't overlap with the actual site, yet it is within 100 feet of its boundaries, the site scores either 3 or 4 depending on whether it is within 50 feet or 50-100 feet, respectively. Because the NWI boundaries are approximate, the assumption is that polygons that are close to a site may actually extend into the site if an on-the-ground delineation was used as a basis for determining the boundaries.

In cases where field delineations of wetlands have occurred, the same ranking scheme is used but the field survey data replaces the NWI data.

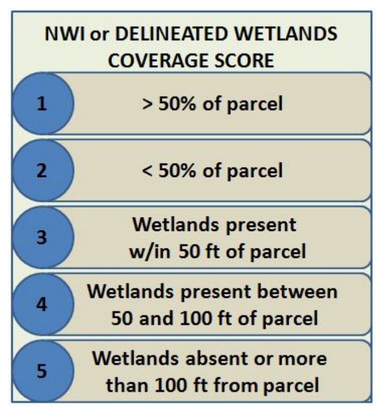

Figure 11: The scoring system for NWI or delineated wetlands coverage within a potential cropland conversion parcel.

Hydric and Non-Hydric Soils with Hydric Inclusions

This factor also approximates the extent of wetland coverage on a given site, but uses soil characteristics as the predictor of wetland presence (based on the U.S. Department of Agriculture (USDA) soils database). Soils that are classified as hydric receive the lowest score (indicating the highest coverage of wetlands), while soils that are not hydric and have no hydric inclusions receive the highest score (indicating the lowest coverage of wetlands). Soils that are classified as non-hydric but with hydric inclusions are ranked intermediately based on their drainage class.

Hydric soils are commonly used to predict the location of wetlands for desktop reviews of sites. While the USDA soils database includes soils mapping done on a somewhat coarse scale, the data can still serve as a useful predictor of the approximate location and extent of wetlands in the absence of field-based wetland boundary data. By including soils that are non-hydric yet contain hydric inclusions within the ranking scheme for this factor, wetlands are likely accounted for that would otherwise be missed if the presence of wetlands were solely based on the major component of a given soil series.

The scoring process for the hydric soil factor follows a weighted mean approach. Scores range from 1, soils whose major component is classified as hydric; to 5, soils that are non-hydric and have no inclusions that are hydric. Scores of 2 through 4 represent soils whose major components are non-hydric but they contain hydric inclusions. The higher the number within this intermediary group, the more well-drained the major component is (e.g., a score of 2 means that, while non-hydric, the major component of the soil series still falls into the somewhat poorly drained category; conversely a score of 4 means the major component is both non-hydric and well drained). Acreages per category are multiplied by that category's rank, summed and divided by the total parcel acreage.

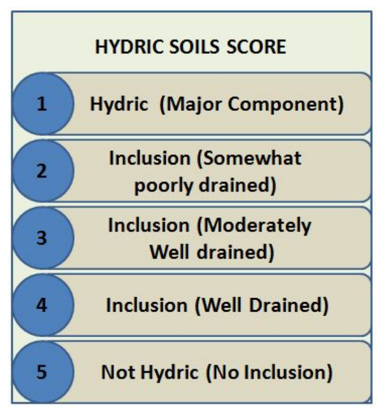

Figure 12: Scoring system for hydric soils within a potential cropland conversion parcel.

Wetland Acreage

The wetland acreage factor estimates the surface area (in acres) of hydric soils and non-hydric soils that are somewhat poorly drained (i.e., those that score 2 under the hydric soil factor ranking scheme). This variable is included in the model to estimate the actual quantity of wetlands within a given site as the other two factors related to wetlands are evaluated based on the percentage of wetlands within a given site.

This factor was included so that the actual quantity of wetlands within a site would be represented by the model, rather than just the ratio of wetland acreage to site acreage. While the hydric soil factor (described above) ranks a site based on its percent coverage by hydric soils (or potential wetlands), it does not include a valuation based on the actual quantity of wetlands present. For example, a large site may score 5 for hydric soils because the majority of acres within the site contain non-hydric soils without hydric inclusions. But, it may still have enough actual acres of hydric soils (although the percentage is low) to make that significant from a standpoint of total wetland acreage. Conversely, a small site with a large percentage of hydric soils for that site may score 1 for hydric soils, yet the actual acreage of hydric soils (or potential wetlands) may be quite small and relatively insignificant compared to the large site that scored more favorably under the hydric soil criterion.

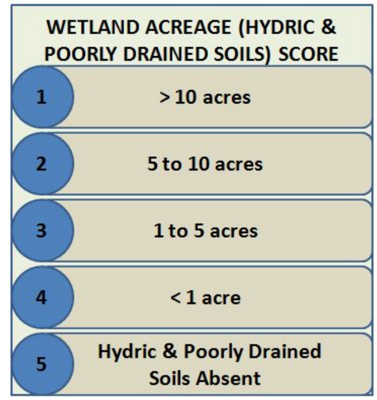

Figure 13: Scoring regime for wetland acreage within potential cropland conversion parcels.

The scoring regime for wetland acreage is illustrated in Figure 13.
Scores range from 1 for sites that contain an estimate of wetland acreage (based on hydric and somewhat poorly drained soils) that exceeds 10 acres; to 5 for sites that contain no hydric or somewhat poorly drained soils mapped on site. Scores of 2 through 4 represent sites that contain wetland acreage estimates of 5-10 acres (score of 2) to less than 1 acre (score of 4). Sites that score 3 contain wetland acreage estimates of 1 to 5 acres.

Proximity to Surface Waters

This factor uses the proximity of the farm field to surface waters as mapped by the Vermont Hydrography Dataset (VHD) to represent the relative impact of the field on nearby surface waters.

Flowing surface waters, whether they are associated with a larger wetland complex or not, are regulated though the Corps Permit process. The VHD provides the most accurate data set of flowing surface waters (stream and river centerlines) available at the statewide scale. The accuracy of the VHD is known to diminish with smaller drainage areas. However, the VHD is the best data option for developing an automated tool that incorporates flowing surface waters. It is the surface water layer most commonly used by GIS professionals and planners in Vermont.

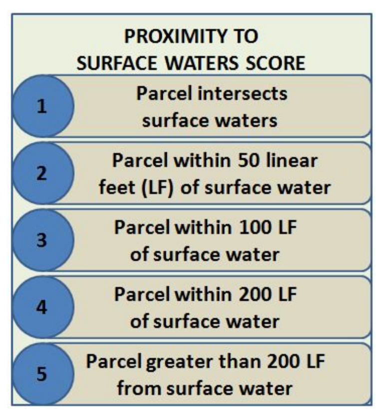

Figure 14: Scoring regime for a potential cropland conversion parcel's proximity to surface water.

A site scores 1 if the field boundary directly impacts the stream channel, such as when a stream runs directly through the field (see Figure 14), or when the field is found immediately adjacent the stream. The factor scoring indicates less impact as the field is found at an increasing distance from the stream, as indicated in the figure above. When a field is greater than 200 feet from a stream, it is considered to have minimal direct impact and the score is 5.

Drainage to Impaired Waters

This factor considers the water quality status of the receiving water body down-gradient of the site. Surface waters which do not meet the VTANR water quality standards are updated once every 2 years by VTANR (303(d) list submitted to EPA) and are available in polyline format from VCGI. T he current dataset used in the model is based on the 2008 303(d) list and was published November 6, 2008.

Streams or other waterbodies that are impacted by surface runoff should be considered when new fields are being selected for conversion to cropland. Stormwater runoff originating from gravel roads, farm fields, or other exposed soils can add significant sediment inputs to streams. If a receiving waterbody is already impaired due to excess sediment or nutrient loading, a new farm field in the drainage area may further degrade the water quality and/or make restoration more difficult.

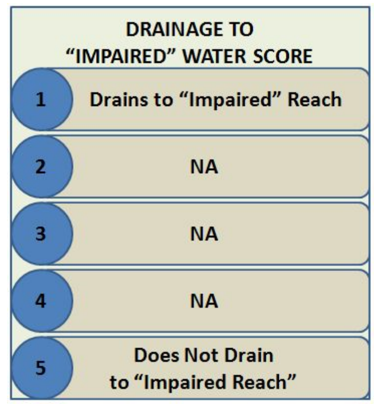

Figure 15: Scoring regime for a potential cropland conversion parcel’s drainage to “impaired” reach.

Since there is no gradient between “impaired” and “not impaired”, the Project Team based scores on two extremes as shown in Figure 15. Under this scheme, a score of 1 is given to fields found within impaired watersheds, and a score of 5 is given to fields in unimpaired watersheds. This scoring scheme has a significant, and sometimes disproportionate impact on the overall natural resource constraint scores when a site is found within an impaired watershed. For this reason, the Project Team recommend reviewing results of grouped constraints as they relate to each other for erosion and surface water conditions. This constraint group includes this factor as well as the following two factors described below: drainage to stream sensitivity, and soil erodibility.

Drainage to Stream Sensitivity

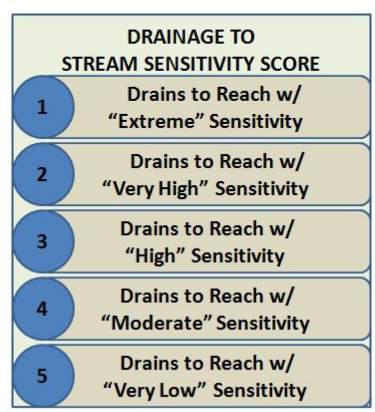

Figure 16: The scoring regime for a potential cropland conversion parcel’s drainage to stream sensitivity.

This factor considers the natural and anthropogenically-modified sensitivity of stream channels to further impacts from altered watershed or riparian corridor conditions. Stream sensitivity data is only available for streams and rivers that have received Phase 2 geomorphic assessments following the VTANR Stream Geomorphic Assessment (SGA) protocols ((Vermont Agency of Natural Resources, 2009). The stream sensitivity rating of the river reach to which the field directly drains (reach subwatershed in which field is found) is used for this factor. If only Phase 1 SGA data has been collected for the study area, a preliminary sensitivity rating can be determined following guidance from the Phase 1 SGA protocols((Vermont Agency of Natural Resources, 2007).If no Phase 1 or 2 SGA data has been collected for the watershed in the study area, this factor should not be applied.

Streams tend to show a gradient of sensitivity from headwaters areas to lower reaches in wider valleys. Steep, headwaters streams tend to have large boulders and bedrock-lined channels that are more resistant to erosion. On the other hand, streams with sand and gravel beds tend to meander within a wider floodplain and have higher erosion rates. If a receiving stream is already highly or extremely sensitive due to natural characteristics or other human impacts, a new farm field in the drainage area may further destabilize the reach and/or make restoration more difficult.

Decreasing scores are given to fields as they drain to stream reaches with a higher sensitivity to impacts, as indicated in Figure 16. Fields draining to reaches with "extreme" sensitivity are given a score of 1, while fields draining to reaches with "low" or "very low" sensitivities are given a score of 5.

Soil Erodibility

Soil erodibility considers the erosion potential of the field based on soil type (and inherent erodibility) and average land slope. The NRCS soils data and a digital elevation model (DEM) available for the entire state was utilized to develop a relationship for predicting soil erosion.

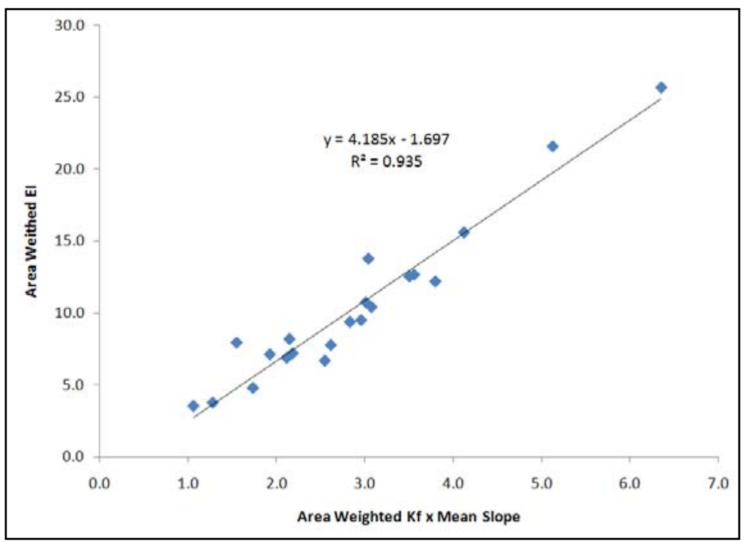

Figure 17: Regression equation and best fit trend line for the relationship between the area weighted Kf x mean slope and the area weighted Erodibility index.

Significant erosion from farm fields results in excess sediment and nutrient loading to downstream waterbodies. NRCS works with farmers to prevent field erosion, both for maintaining long-term soil productivity and preventing impacts to water quality. The NRCS uses GIS and field-based data to determine whether a field is found on highly erodible lands (HEL) based on the average Erodibility Index (EI) of the field. For the purposes of this GIS model, the calculations used to determine the Erodibility Index (EI) were reviewed to determine if a ranking scheme for soil erodibility could be developed with GIS data alone. Based on a review of the fields used in this study, the Project Team determined that the Kf factor, an erosion statistic found in the NRCS soils data and used in the Revised Universal Soil Loss Equation (RUSLE), in combination with average field slope is an excellent predictor of EI (see Figure 17). The Project Team found that area-weighted

Kf for the upper 10 inches of the soil multiplied by mean field slope explained approximately 94% of the variance in EI. This calculation was automated into the NFAST model.

Decreasing scores (see Figure 18) are applied to those fields with higher slope and more erodible soils as predicted by the NRCS data, as shown in the ranking scheme to the right. The fields with the highest potential for soil erodibility are those with values greater than 6. The fields with the lowest potential for soil erodibility are those with values less than 1.5. For the Magnan pilot project, the Project Team found that the greatest number of fields to score a 4 (low-moderate erodibility). This reflects the initial field selection approach, whereby fields with greater slopes and less productive (and more erodible) soils were generally discarded.

SOIL ERODIBILITY (RUSSELL K x % SLOPE) SCORE	
1	K x % Slope > 6.0
2	4.5 < K x % Slope ≤ 6.0
3	3.0 < K x % ≤ 4.5
4	1.5 < K x % ≤ 3.0
5	K x % ≤ 1.5

Figure 18: The scoring regime for the soil erodibility of a potential cropland conversion parcel.

Deer Wintering Yard

Deer wintering yards are the habitats that white tailed deer use during the winter months when climate conditions contribute to mortality. Deer wintering habitat is defined by the Vermont Fish and Wildlife Department as "areas of mature or maturing softwood cover, with aspects tending towards the south, southeast, southwest, or even westerly and easterly facing slopes." These habitats provide shelter from deep snow and extreme wind chill events. Deer winter yards generally consist of northern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), northern white cedar (*Thuja occidentalis*), spruce (*Picea* sp.), and fir (*Abies* sp.) Without wintering yard, deer populations would likely be vulnerable to annual fluctuations due heightened levels of mortality during moderate and severe winters (Vermont Fish and Wildlife Department)

Deer wintering yards are included in the GIS model due to regulatory protection granted under the Vermont Wetland Rules, which state that agricultural uses are an allowed use provided that clearing of vegetation within existing deer winter yards does not occur.

The scoring for deer wintering yard is illustrated in Figure 19. If deer winter yards are present within a potential cropland conversion parcel, a score of 1 is merited. A score of 5 indicates that deer wintering yard is absent from the parcel.

DEER WINTERING YARD SCORE	
1	PRESENT
2	NA
3	NA
4	NA
5	ABSENT

Figure 19: Scoring regime for deer winter yard within a potential cropland conversion parcel.

Rare, Threatened, or Endangered Species

Plants and animals that are state and federally listed as rare, threatened, or endangered (RTE) are protected from harm ("takings") by any activity via the Vermont Endangered Species Law (10 VSA Chapter 123) and the federal Endangered Species Act. Observations of RTE organisms on lands throughout Vermont have been documented by the Vermont Fish and Wildlife Department Natural Heritage Program. The NFAST model includes database information on the locations of an RTE population. Any land development activity, including cropland conversion, must determine if an RTE population is located at or within the vicinity of the project site. If an RTE population is present, the parcel would merit a score of 1, and a more detailed investigation of the natural community would be warranted. If no RTE populations are present, the parcel would merit a score of 5 (see Figure 20).

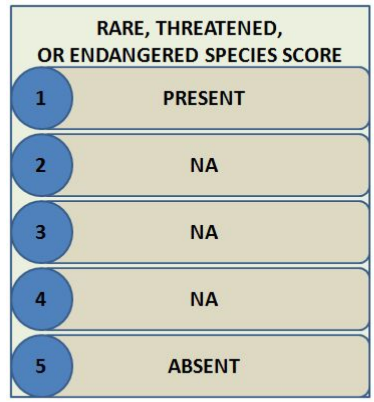

Figure 20: The scoring regime for RTE evaluation of a potential cropland conversion parcel.

Natural Communities

A natural community is an interacting assemblage of organisms, their physical environment and the natural processes that affect them (Thompson & Sorenson, 2000). The organisms include all the plants, animals, insects, fish, birds, amphibians, and reptiles that live within a landscape with distinct physical settings and climate conditions. The physical settings that help define the natural community are readily visible when walking through a landscape and include features such as bedrock, surficial deposits, topography, hydrology, and soil. The natural processes that affect the organisms and the physical environment include wind, ice and snow loading, fire, flooding, and the movement of water and ice. Thompson and Sorenson document 80 natural community types consisting of 40 upland communities and 40 wetland communities. A mesic red oak-northern hardwood forest is an example of a forested upland community. A silver maple-ostrich fern riverine floodplain forest is an example of a forested wetland community.

Figure 21: Scoring regime for the natural communities occurring on potential cropland conversion parcels.

Natural communities have been included in the NFAST model as they can be rated as to the frequency of their occurrence, and thus help regulators assess whether impacts to a particular community are warranted or if the impacts to a particularly rare community would be pose unacceptable risks to unique habitats. The Vermont Nongame and Natural Heritage Program has created a state ranking system that indicates the relative rarity of the natural community types. These rankings are:

- S1: extremely rare in the state, generally with fewer than five high quality occurrences.
- S2: rare in the state, occurring at a small number of sites or occupying a small total area of the state.
- S3: high quality examples are uncommon in the state, but not rare; the community is restricted or threatened for reasons of climate geology, soils, or other physical factors, or many examples have been severely altered.
- S4: wide spread in the state, but the number of high quality examples is low or the total acreage occupied by the community type is relatively small.
- S5: common and widespread in the state with high quality examples easily found.

The scoring regime within the NFAST model is based on the S1 through S5 designation, as shown in Figure 21. A ranking of S1 merits a score of 1, while the ranking of S5 merits a score of 5.

Cultural and Historical Significance

The Vermont Division for Historic Preservation has developed a GIS-based mapping system called "VermontArcheoMap" that allows users to view and better understand potential locations of precontact Native American sites in Vermont. Map layers derived from a GIS-based geoprocessing model that emulates portions of the Vermont Environmental Predictive Model comprise the core of the VermontArcheoMap information system.

Areas of cultural and historical significance need to be considered for crop conversions due to the potential impact on important archeological sites. The Corps permit process, as well as other Vermont state regulatory processes such as Act 250, require a review of cultural and historical significance to rule out impacts from agricultural conversions and land development.

Eleven map layers in VermontArcheoMap are thought to represent environmental or cultural factors conducive to precontact habitation and resource extraction activities. The eleven analytical layers are: drainage proximity, waterbody proximity, wetland proximity, drainage-waterbody proximity, drainage-drainage confluence proximity, head of drainage proximity, waterfall proximity, paleo lake soils proximity, glacial outwash and kame terrace soils presence, floodplain soils presence, and level terrain presence. This geospatial model can be viewed by authorized state personnel on a web-based interface provided by the Vermont Division for Historic Preservation. Due to the sensitivity of this information and limited

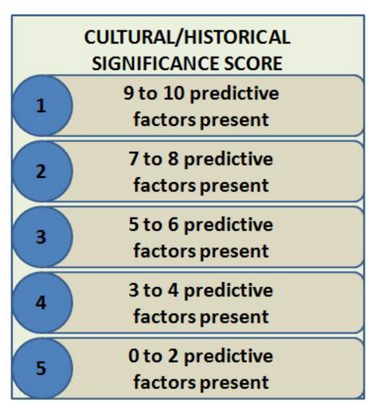

Figure 22: The scoring regime for the cultural/historical significance of a potential cropland conversion parcel.

access to the public, the data layers could not be incorporated into the NFAST model. However, the web-based mapping can be reviewed and results can be incorporated *ad hoc* into the model results based on the following ranking scheme: 1) 9 to 11 predictive factors are present; 2) 7 to 8 predictive factors are present; 3) 5 to 6 predictive factors are present; 4) 3 to 4 predictive factors are present; 5) 0 to 2 predictive factors are present.

Project Progression and Model Evolution –A Timeline of Activities and Key Events

The development of the NFAST program was initiated at a kickoff meeting on August 13, 2009. Meeting participants are listed in Table 1. During the kickoff meeting, the initial project approach was described, tasks were identified, and a schedule was established.

Table 1: List of participants at the NFAST project kickoff meeting on August 13, 2009.	
VWPS Team	**Vermont Agency of Natural Resources**
Dan Redondo (VWPS)	Julie Moore (Center for Clean and Clear)
Shelley Gustafson (SGE)	Alan Quackenbush (DEC Wetlands)
Evan Fitzgerald (FEA)	
Brian Jerose (WNRS)	**U.S. Army Corps of Engineers**
Dave Whitney (ES)	Marty Abair
Alicia Daniel	Mike Adams
Vermont Agency of Agriculture	**USDA NRCS**
Laura DiPietro (Water Quality Section)	Kip Potter
Dairy Producers	**U.S. Environmental Protection Agency**
Mark Magnan (Program Participant)	Beth Alafat
Bill Rowell	

September 2009

Consistent with the first objective, the Project Team prepared draft maps of all 13 tracts owned by Magnan. Digital information on the 13 tracts was provided by the U.S.D.A. Farm Service Agency.

The Project Team then met with Magnan and identified candidate parcels for conversion to cropland. Many of the parcels would be extensions of existing crop fields. Map features such as soil types, topographic features, streams, and U.S. Fish and Wildlife Service National Wetlands Inventory data were used in identifying the most promising parcels. The candidate parcel boundaries were drawn by hand and then digitized using GIS software (ESRI ArcGIS 9.3.1).

With the parcel boundaries digitized, the Project Team used the digital database for the Soil Survey of Franklin County, Vermont to identify potential crop production values for each parcel. As each parcel could contain multiple soil types, the Project Team used a weighted means approach to calculate the potential yield for the entire parcel. The weighted means approach assigns weight to the soil type's potential crop production based on the soil type's percentage of the total parcel acreage, and then calculates an average for the entire parcel. For example, if a 10-acre parcel consists of three soils with the following sizes and yields, the potential crop yield of corn silage would be 4.5 tons per year.

Soil Type A: 7.0 acres (70% of parcel), potential corn yield of 5 tons per acre
Soil Type B: 2.0 acres (20% of parcel), potential corn yield of 4 tons per acre
Soil Type C: 1 acre (10% of parcel), potential corn yield of 2 tons per acre.

$$Weighted\ Means\ Yield = \frac{((Y_a * P_a) + (Y_b * P_b) + (Y_c * P_b))}{(P_a + P_b + P_c)}$$

$$Weighted\ Means\ Yield = \frac{((5 * 0.70) + (4 * 0.20) + (2 * 0.10))}{(0.70 + 0.20 + 0.10)}$$

This weighted means approach is used throughout the NFAST program wherever a factor is scored based on the acreage of a soil type.

October 2009

The Project Team met again with Magnan to review the potential crop production yields for each parcel. Based on this review process, several parcels were dismissed as candidates due to low crop production values and several parcel boundaries were re-drawn to include productive soils or exclude unproductive soils. Through this iterative process, 19 parcels were identified as prime cropland conversion candidates. The 19 parcels totaled 316.6 acres and ranged in size from 2.4 acres to 36 acres. The average parcel size was 14.4 acres.

November 2009

The Project Team met again with Magnan and conducted a partial site visit to assess if the 19 parcels were indeed prime candidates for cropland conversion. A total of 14 sites were inspected for features such as site stoniness, depth to bedrock, hydric soils, and wetlands were present as indicated on the maps. The site assessment was deemed successful, as information identified in the maps matched well with on the ground conditions. There were, however, instances where the site assessment revealed wetlands on non-hydric soils and a stream channel that was not identified in digital databases.

The Project Team and the Working Group met on November 20, 2009 to discuss the progress to-date, the methods used to indentify parcels for conversion to cropland, and the parcel maps prepared in October. The Working Group requested that Magnan prepare a project goals statement in which his growth objectives are identified along with his plan for feeding the expanded herd by either purchasing off-farm feed or by growing corn and hay on converted cropland. The Working Group also presented flow-accumulating maps produced by Reed Simmons of the Vermont NRCS. These maps were developed using high-resolution digital elevation models to identify drainage networks through the landscape. Initially, these maps had significant appeal, as they could be used to help predict the presence of wetlands and to identify locations for potential mitigation projects. However, their utility was later determined to be limited, as the high-resolution data, which is developed through an expensive and lengthy process known as LIDAR (**L**ight **D**etection **A**nd **R**anging) is not available for most regions of the state.

December 2009

The Project Team and the Working Group met in mid-December to confirm the factors within the Natural Resource and Producer constraints. The Working Group suggested or directed the Project Team as follows:

Hydric Soils

- Examine a list of Vermont inclusion soils that are more likely to be hydric soils than not, and that the Project Team might want to use this to flesh out the rankings, which at the time were based on a hydric soils (score of 1), inclusion soils (score of 3) and non-hydric soils (score of 5).
- Evaluate using the hydrologic drainage class to flesh out the scoring system.

NWI Wetlands

- Evaluate the condition of the wetland based on U.S. Fish and Wildlife, such as whether the NWI parcel is already in agricultural production, is a manure pit, or a man-made pond.
- List the total acreage of NWI wetlands and hydric soils that are within the parcels that have been identified for potential conversion.

Highly Erodible Lands

- Discard the use of the Highly Erodible Lands (HEL) value, as it is based on an unreliable slope class and a T agronomic unit factor and has no relationship to water quality. Also, the HEL value varies considerably from soil survey map to soil survey map.
- Consider using the Digital Elevation Model (DEM) slope and K factor (from the RUSLE model) as an alternative method.

Connectivity to Flowing Surface Waters

- Change “Connectivity to Flowing Surface Waters” to “Connectivity to Surface Waters”, as the term “flowing” refers to only one type of surface water and excludes ponds and lakes.

Drainage to Stream Geomorphic Sensitivity

- Evaluate the inclusion of “ditched” as an un-ranked category.

Natural Communities

- Consider using biotic data not available to the general public

Wildlife

- If possible, include proximity to large parcels, such as important wildlife corridors, deer yard, and bear habitat.

Cultural/Historical

- Talk with the Division of Historic Preservation about acquiring their digital database.

Average Land Slope

- Eliminate the 25% rank and replace it by spreading out the other slopes.

Flood Frequency

- Define “frequent”, “common” and “duration.”

Cost of Conversion

- Cost of conversion was initially considered as a producer constraint. Both the Project Team and the Working Group recognized that estimating the cost of conversion would likely involve greater efforts beyond the screening level.

The Project Team and the Working Group also discussed using ranking systems to identify which parcels should be considered candidates for cropland conversion. Several problems with ranking parcels are that data behind the rankings is hidden and that wetland impacts may be covered up by other factors that score high. One solution would be to provide the raw data for each parcel. Conversely, the ranked data could provide utility to the dairy farmer, as this would allow for attention to be focused on productive lands with little impacts to wetlands and natural resources.

January 2010

The Project Team completed a draft of the Natural Resources and Farm Assessment and Screening Tool. NFAST was built on the ArcGIS® Modelbuilder platform with transferability to other Vermont farms in mind. NFAST uses a total of 156 processes from the ArcGIS® toolbox to automate spatial analyses and develop separate scores for Producer and Natural Resources Constraints. Key points of the NFAST Version 1.0 include:

- Native Vermont GIS data sets (available through VCGI) have been used to the maximum extent possible to ensure repeatability and transferability of the tool to other farms throughout Vermont.

- Equal weighting of the factors that comprise the producer and natural resource constraints.

- At the December meeting, the Working Group recommended various alternatives for ranking of factors when the initial ranking only contained two potential ranks (1 or 5, effectively a presence/absence scenario), or three ranks (1, 3, or 5). One such factor was the hydric soils, which the Project Team subsequently expanded from 3 rankings to 5 rankings by subdividing the inclusion rating into three categories: poorly drained soils with hydric inclusions, moderately drained soils with hydric inclusions, and well drained soils with hydric inclusions.
- The Producer Constraint model uses four input data sets to generate scores that reflect the desirability of a field for conversion to agricultural production. These inputs include: potential field boundaries, NRCS soils data, a digital elevation model (DEM), and 100 year flood zones.

- The Natural Resources Constraint model uses eight input data sets to generate scores that reflect the overall predicted impacts to natural and cultural resources, where low scores reflect greater impacts. These inputs include: potential field boundaries, NRCS soils data, surface waters, NWI wetlands, subwatersheds, rare/threatened/endangered species mapping, deer wintering yards, and cultural and historical significance.

- The Project Team explored the possibility of reducing the data preparation steps for the soils data. Martha Stuart from Vermont NRCS provided an Access database of all soils parameters for Franklin County, and the Project Team incorporated the full database into NFAST to reduce manual data entry and potential for error.

NFAST was used to screen 21 potential parcels (two parcels were added in early January). The results of the screening were organized into constraint and final scores by field. Constraint subtotal scores and overall scores were ranked to facilitate comparison of each criterion's influence on the scores.

Two sets of maps were also prepared to facilitate review. The first set of maps identified the parcels identified for potential conversion to crop, hay, or pasture. These maps contained all the producer and natural resource constraint factors used to screen each site, but did not include the constraint and final scores. The maps were issued to the Working Group for conducting a "blind" review.

The second set of maps identified the parcels with draft constraint and total scores and ranks. This set of maps identified the parcels that the model predicted would be candidates for converting to crop production with the least impacts to natural resources.

February and March 2010

The Project Team made several revisions to natural resource constraint factors. First, the HEL was relabeled as “Erodible Soils”. It was determined that the Kf factor, an erosion statistic found in the NRCS soils data and used in the Revised Universal Soil Loss Equation (RUSLE), in combination with average field slope is an excellent predictor of EI.

The second revision increased the sensitivity of the Wetland Acre factor by including soils that were not hydric but were poorly drained with hydric inclusions. The Project Team observed that, in many instances, wetlands were located on non-hydric soils, and that the addition of soils that were poorly drained would better identify parcels that were likely to contain wetlands.

The third revision adjusted the NWI Wetlands factor to include delineated wetlands, if a field survey had been conducted for a given site. The factor was set to use locally delineated wetlands and, when absent, revert to NWI criteria.

June 2010

The Project Team and the Working Group conducted a site assessment on June 15 at the Magnan farm to assess the validity of the GIS model to accurately identify potential parcels for crop conversion and the natural resources, in particular wetland and stream features, located on each parcel. At seven walk-through parcels, participants looked for: 1) presence of wetlands and/or streams where the model indicated hydric soils existed; 2) opportunities to adjust parcel boundaries to reduce impacts to wetlands and/or streams; and 3) parcels that should be dismissed as candidates for crop conversion due to a preponderance of wetlands and/or streams.

Overall, the Project Team and the Working Group agreed that the NFAST predicted where wetlands would be found through the use of hydric soils and poorly drained, non-hydric soils with hydric inclusions.

It was recognized that the NFAST output does not replace reviewer evaluation of contour elevation lines on each parcel for distinct features, as wetlands are frequently associated with breaks in slope, concave features, or saddles between two drainage features.

The site assessment revealed that the NFAST model can overestimate the quantity of wetlands by still using the hydric soil data to predict wetland presence when wetland delineations had been conducted for a site, and were included in the model. Under this circumstance, the user/reviewer of the model results should account for the presence of the delineated wetland and discount the use of hydric soils (and non-hydric, poorly drained soils with hydric inclusions) as a surrogate for wetland presence.

The importance of parcel boundaries was also discussed as a necessary step for reducing impacts as predicted by NFAST. For instance, if a parcel boundary is adjusted to exclude hydric soils, then the overall score for the parcel would increase and the parcel could become a candidate for cropland conversion.

In response to continued concerns about ranking systems as method for selecting parcels, the Project Team proposed dividing the natural resource constraint factors into three groups: (1) Army Corps Regulated, which includes the factors NWI wetlands, hydric soils, wetland acreage and, proximity to surface waters; (2) Erosion and Surface Water Condition, which includes the factors drainage to impaired waters, drainage to stream sensitivity, and soil erodibility; and (3) Natural Community, Habitat, and Cultural. The Project Teams also proposed including the scores per producer and natural resource constraint factors on the back side of each parcel map. The Working Group agreed that both suggestions were sensible improvements.

July 2010 - Final Revisions to the Model

Based on the conclusions reached during the site walk, the Project Team revised the model to adjust parcel boundaries where appropriate to minimize potential impacts to natural resources, in particular streams and wetlands. Additionally, the model output now included data sheets and grouping of natural resource factors on the back side of each map. The data sheet contained:

- shortest distance to surface waters (feet)
- hydric soils (acres and % of field)
- predicted wetland acreage based on hydric ranks 1 and 2 (acres and % of field)
- NWI impacts, including any delineated wetlands (acres and % of field)
- mean field slope
- mean Kf (erosion factor) for field
- average and gross corn/hay silage yield per acre
- field soils summary (including soil type and acreage)

The results of the model are provided in graphical and tabular format in Appendix A.

September 2010 – Site Selection for Field Evaluation

Based on the final results of the model and associated mapping, Magnan selected a total of 11 sites (approximately 110 acres) to evaluate in the field for the presence and extent of wetlands. The sites are representative of the range of final scores, both for the producer and the natural resource constraint categories. Table 2 summaries the areal coverage of hydric soils, poorly drain non-hydric soils with hydric inclusions, and NWI or delineated wetlands per parcel.

Table 2: Summary of hydric soils, poorly drained non-hydric soils with hydric inclusions, and NWI or delineated wetlands on the 11 parcels recommended for cropland conversion.

PARCEL/FIELD	HYDRIC SOILS (ACRES)	POORLY DRAINED NON-HYDRIC SOILS WITH HYDRIC INCLUSIONS (ACRES)	NWI OR DELINEATED WETLANDS (ACRES)
685-D	1.12	4.52	0.20
685-C	0.40	9.56	0.0
1215-A	0.05	3.04	0.0
9884-D	0.0	0.08	0.0
688-B	0.0	1.48	0.0
688-A	0.0	6.60	0.0
9929-C	0.0	2.44	0.0
685-A	7.03	4.01	0.40
771-A	3.88	5.18	0.0
9929-A	0.0	2.82	0.0
9884-C	0.0	0.13	0.0
TOTALS	**12.48**	**39.86**	**0.6**

Field delineations of all wetlands identified within the 11 sites will be conducted as a component of Phase II of this project. The results of the delineation will be ultimately used to quantify impacts for the Corps permit process.

As a participant in the project, Magnan developed a project goals statement which describes their expansion objectives in terms of herd increase (from 750 milking cows to 950 milking cows), feed requirements to meet the increased herd size (2,250 additional tons of corn silage and 3,350 tons of grass haylage), and acreage (391 acres) to produce the required feed. The goals statement is provide on page 1 of Appendix B. In preparing the goals statement, Magnan answered a questionnaire provided by the Army Corps. This questionnaire and associated feed spreadsheet is provided on pages 3 through 6 of Appendix B.

The estimated annual feed requirement to meet the increased herd size would be 2,250 additional tons of corn silage and 3,350 tons of grass haylage

The Farm currently operates with 750 milking cows, 100 dry cows and 450 replacement heifers, and plans to increase the size of the herd to 950 milking cows, 100 dry cows and 600 replacement heifers over the next five years.

Conclusions

The NFAST model is a powerful tool that will simply the Army Corps permit process. The model allows dairy farmers and NRCS extension agents to quickly identify potential new cropland conversion parcels. The model quantifies and graphically depicts wetlands (or surrogates for wetlands such as hydric soils and poorly drained non-hydric soils with hydric inclusions) and significant natural resources to assist state and federal regulators assess potential impacts. And lastly, the model allows for minimization of impacts to wetlands and significant natural resources throughout the process, as parcel boundaries can be readily adjusted to avoid areas containing these critical features.

It is important to understand that the NFAST model does not eliminate the need for human evaluation of site conditions. But the true power of the NFAST model resides in its ability to automatically calculate parcel values for essential producer and natural resource constraint factors, such as corn silage yield and hydric soils. As parcel boundaries are adjusted throughout the process, the dairy farmer and state/federal regulatory staff can quickly re-calculate projected impacts, identify parcels as candidates for cropland conversion, and efficiently direct field resources to delineate wetlands on those candidate parcels. As such, the Project Team believes the NFAST model will be successfully used by dairy farmers and NRCS extension agents to simply to Corps permit process.

Bibliography

1) Thompson, E. H., & Sorenson, E. R. (2000). *Wetland, Woodland, and Wildland: A Guide to the Natural Communities of Vermont.* Hanover, NH: The Nature Conservancy and the Vermont Department of Fish and Wildlife.
2) U.S. Department of Agriculture. (2007). *National Agriculture Statistics Service.* Washington, D.C.: U.S. Department of Agriculture.
3) U.S.D.A. Soil Conservation Service. (1979). *Soil Survey of Franklin County, Vermont.* Washington, D.C.: United States Department of Agriculture.
4) United States Department of Agriculture Soil Conservation Service. (1961). Land capability classification. In *U.S. Department of Agriculture Handbook 210.*
5) Vermont Agency of Natural Resources. (2007). *Stream Geomorphic Assessment - Phase 1 Handbook Watershed Assessment: Using Maps, Existing Data, and Windshield Surveys.* Vermont Agency of Natural Resources.
6) Vermont Agency of Natural Resources. (2009). *Stream Geomorphic Assessment - Phase 2 Handbook. Rapid Stream Assessment Field Protocols.* Vermont Agency of Natural Resources.